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People, lakes and seashores: Studies from the Baltic Sea basin and adjacent areas in the early and Mid-Holocene

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ABSTRACT

During the Early and Mid-Holocene significant changes in the ecology and socio-cultural spheres occurred around the Baltic Sea. Because of the underlying climatic changes and thus environmental alterations, the area was the scene for various cultural developments during the period under investigation. In the course of the melting of the glaciers at the end of the last Ice Age, isostatic and eustatic movements caused continual changes to the Baltic Sea basin. Changes in water level, however, affected not only the Early and Mid-Holocene coastlines, but also the whole Baltic Sea drainage system, including large lakes, rivers and watersheds in the hinterland were also dramatically impacted by these ecological changes. Prehistoric people were thus affected by changes in resource availability and reduction or enlargement of their territories, respectively. In order to evaluate the impact of changes in the water and land networks on the environment, resource availability, and human behaviour, and to reconstruct human responses to these changes, we pursue an interdisciplinary approach connecting environmental and archaeological research highlighted through different case studies.

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1. Introduction

During the Early and Mid-Holocene, people living around the Baltic Sea experienced great variations in their relationship with their environment. After palpable changes, catastrophic events in some cases, in the relationship between land and water during the Late Pleistocene, the changes that occurred in the subsequent millennia were slower, but they had just as lasting effects on humans. Consequently, human populations had to adapt and transform established behaviours and settlement system and develop new coping mechanisms (e.g. Björck, 1995a; Schmölcke et al., 2006; Stroeven et al., 2016; Sørensen et al., 2013; Terberger, 2004). Isostatic and eustatic processes caused a wide range changes to environments around the Baltic Sea (e.g. Andrén et al., 2011; Björck, 1995b). For instance, in the northern part, at the latitude of Central Sweden, an archipelago emerged and grew (e.g. Björck, 1995a; Swärd et al., 2017). Early use of this landscape thus required boats. The archipelago landscape gradually came to serve as a bridge in contacts between present-day Sweden and Finland. The results of shoreline displacement with increased land masses were also significant for settling inland, not least for the relationship between the coastal area and larger lakes. While Gotland was colonised, there is also evidence of contacts between the coast and inland around the Baltic Sea (Boethius et al., 2017). Further south, in the area of the modern-day southern Baltic Sea coast, shoreline displacement evolved differently as considerable areas of land were gradually inundated. Due to the changing shoreline, Bornholm was gradually isolated from the continent (e.g. Björck, 1995a). However,

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a noticeable submerging of the coasts need not always have had negative consequences. Since when parts of the Baltic area became available for settlement due to upheaval, other inundated parts were indeed consequently lost as territories but transformed into fishing grounds, for instance (cf. Tallavaara and Seppa, 2011, 221). The nutrient content increased or the salinity of the water changed in a way that benefited fishing or seal hunting. From southern Denmark and northernmost Germany, there is an extensive body of evidence about submarine settlement remains today (e.g. Fischer, 1987, 1995; Grøn, 2011; Hartz et al., 2014; Klooß, 2015; Lübke et al., 2011; Terberger, 2007; Warden et al., 2017).

The emergence of new and breaking off of old communication corridors had to be faced as well as adjustments in different spheres of daily life. Thus, changes in the landscape did not only have physical consequences, they also helped shaping the conceptual world that governed ideas and norms of people. Besides long-term changes which influenced Prehistoric people, short term climatic oscillations were affecting the Early and Mid-Holocene hunter-gatherers as well. While these are sometimes discussed as one of the triggers leading to sedentary lifeways and other cultural changes in the Mediterranean and Central Europe (e.g. Dolukhanov, 1997; Gehlen and Schön, 2005; Gronenborn, 2010; Wicks and Mithen, 2014; Woodman, 2009), the northern European Mesolithic has rarely been discussed in this respect (cf. Breivik et al., 2017; Manninen, 2014).

The present study aims to give an overview of recent advances in the archaeology of the Baltic Sea basin and adjacent areas (Fig. 1). We pursue to present an interdisciplinary approach by bringing together evidence from environmental and archaeological research, which serves to evaluate human-environment interactions in the region. The impact of environmental and geographical changes on resources and human societies is discussed through various case studies from around the Baltic Sea. Alongside a brief summary of climatic oscillations and their impact, the case studies will highlight aspects of modern research on Early and Mid-Holocene hunter gatherer populations. Incorporating ethnoarchaeological perspectives further underlines current challenges and possibilities of Mesolithic research around the Baltic Sea basin and adjacent areas.

2. Early Holocene climate oscillations in northern Europe – a discussion of the available evidence and its possible implications

There is a long-living notion of favourable weather conditions during the Mesolithic in central and northern Europe associated with the pronounced rapid warming during the early Holocene. Nevertheless, over the past decades, a growing number of palaeoenvironmental records have testified a higher than assumed climatic variability during the early Holocene in the area. Evidence has been found in ice cores (e.g. Alley et al., 1997; Thomas et al., 2007), marine sediments (e.g. Bond et al., 1997, 2001), glacier dynamics (e.g. Matthews et al., 2000; Seierstad et al., 2002), lake sediments (e.g. Björck et al., 1997; Boettger et al., 2009; Magny et al., 2007; Prasad et al., 2007; Von Grafenstein et al., 1998; Zolitschka and Negendank, 1998), tree rings (e.g. Spurk et al.,

Fig. 1. Location of discussed sites in modern Europe (base map: © EuroGeographics for the administrative boundaries).

2002), and slope deposits (e.g. Dreibrodt et al., 2010a).

2.1. Climate oscillations

The most pronounced phases identified by oscillations of the oxygen isotopes in the Greenland ice cores are the Preboreal Oscillation (PBO) around 11,300 cal. BP, the 9300 cal. BP phase, and the 8200 cal. BP phase (Rasmussen et al., 2007, Fig. 2).

Most terrestrial records correlated to early Holocene climate oscillations are based on palaeovegetation proxies. One of these, the PBO, was recognised early in the vegetation of western and northern Europe and is widely recorded (e.g. Ammann et al., 1994; Behre, 1978; Björck et al., 1997; Bohncke and Hoek, 2007; Bos, 2001; Bos et al., 2007; Haas et al., 1998; Litt et al., 2009; Lotter et al., 1992; Ralska-Jasiewiczowa et al., 2003; Stančikaitė et al., 2009; Van Geel et al., 1981; Wick, 2000). Björck et al. (1997, 2001) identified the PBO as a cold phase and report high allochthonous input into ancient lake Torreberga (Sweden) during this phase. They conclude that "the increased input of allochtonous carbonates indicate enhanced surface runoff as a consequence of increased precipitation and/or unstable soil conditions, […]" (Björck et al., 1997, 458). Thus, a moister than usual climate or a destruction of the vegetation cover-e.g. by wildfires- and resulting erosion of uncovered surface soils can be inferred from this data in the catchment area.

During the 8200 cal. BP phase dry and cold climatic conditions characterised the Northern Hemisphere for ca. 150–160 years (e.g. Baker, 2012; Thomas et al., 2007). While the climate was cold and dry, particularly in winter, the summers in Scandinavia might have been cool and wet (Alley and Ágústsdóttir, 2005; Baker, 2012). According to Magny and Bégeot (2004) and Magny et al. (2003, 2007) the circum-alpine region experienced wet conditions too, but northern and southern Europe were generally drier during this phase. Remarkable changes also occurred in the vegetation cover of northern and central Europe (Baker, 2012). Besides the palaeobotanical evidence, early Holocene climate oscillations have been recognised in palaeozoological records (e.g. Brooks, 2000; Brooks and Langdon, 2014; Coope et al., 1998; Kulesza et al., 2012; Płóciennik et al., 2011). In addition to the pronounced climate oscillations at ca. 11,300 and 8200 cal. BP there is an indication for further climate deterioration phases at ca. 10,300 and 9300 cal BP from marine (Bond et al., 1997, 2001) and terrestrial records (e.g. Brüchmann, 1998; Zolitschka and Negendank, 1998; Dreibrodt et al., 2010a). Dreibrodt et al. (2010a) found slope instability in northern Germany probably triggered by wildfires during the 10.3 and 9.3 ka BP climate oscillation phases. Limnological response to 10.3 and 9.3 ka climate oscillation was detected in annually laminated sediments of Lake Holzmaar but differed between both phases. Whereas the 10.3 ka BP oscillation is reflected by increased allochthonous input (Zolitschka and Negendank, 1998) the 9.3 ka BP oscillation is clearly visible in the diatom record (Brüchmann, 1998).

2.2. Geomorphologic activity

A clear increase of geomorphologic activity during the early Holocene has been recorded in lake and slope systems by high allochthonous input in lakes (e.g. Björck et al., 1997; Zolitschka and Negendank, 1998) during the oscillation phases which are also reflected in isotopic records of lake sediments (e.g. Von Grafenstein et al., 1998; Wennrich et al., 2005). Dreibrodt et al. (2010a) analysed slope deposits during the early Holocene climate oscillation phases, presented data for a slope in eastern Germany and compiled data from additional German sites. Natural wildfires were the probable trigger for the observed slope instability, promoted by the prevalence of highly inflammable conifer forests (see also Crombé, 2016).

The record of fluvial and aeolian systems is more intricate.

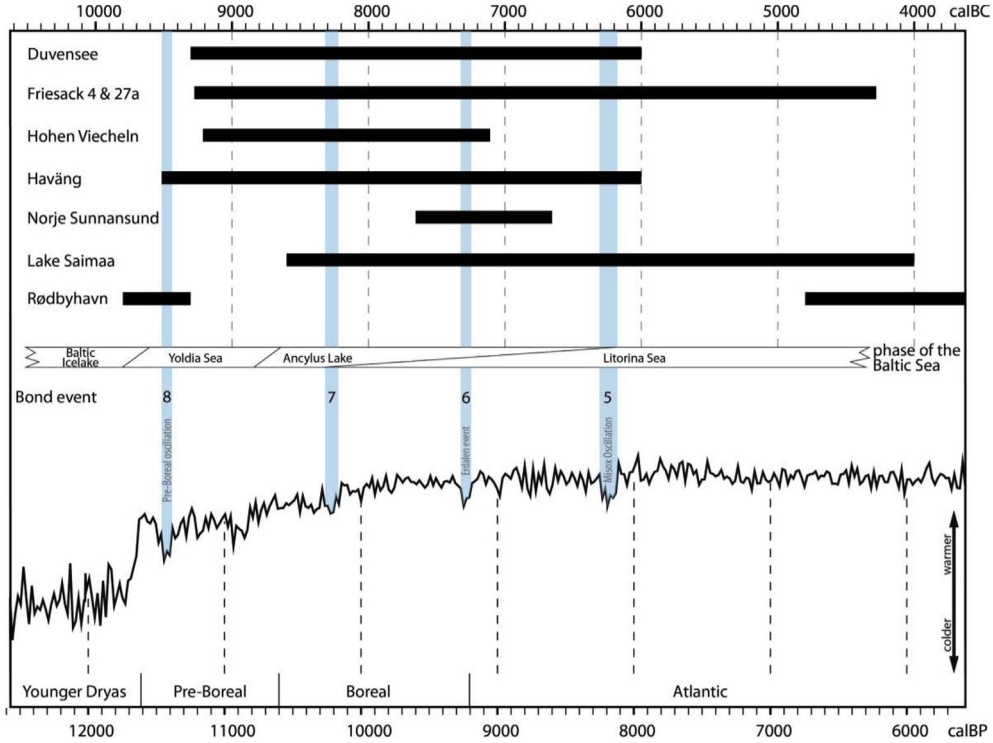

Fig. 2. Chronology of sites described in the text, climate events, phases of the Baltic Sea and palynological chronozones of Northern Central Europe (curve: OxCal 4.2.4 Bronk Ramsey and Lee, 2013; Reimer et al., 2013; see text for further references).

Stability of the central European fluvial systems in the early Holocene has been emphasised by one group of researchers (e.g. Dreibrodt et al., 2010b; Notebaert and Verstraeten, 2010). This is mainly based on the Holocene diachronous history of alluvial overbank fine deposition as an unequivocal indicator for palaeofloods. Other researchers have reported episodes of increased fluvial activity during the early Holocene (e.g. Hoffmann et al., 2008; Kittel et al., 2016; Lewin et al., 2005; Macklin et al., 2006; Starkel et al., 2006). This latter group included data from channel fills and soils to support their interpretation, which may be seen as ambiguous, since these components can be found contemporaneously and neighbouring in most alluvial systems and are therefore less indicative of the intensity of alluvial activity than overbank fines (c.f. Bos et al., 2007, Storme et al., 2017).

There seems to be a west-eastward-gradient of the recorded aeolian activity in northern and central Europe. In extensive studies of dune fields in northern and eastern Germany (Hilgers, 2007) few deposits have been found that date to the early Holocene (see also Lungershausen et al., 2017; Mauz et al., 2002). A higher number of early Holocene aeolian deposits has been reported from Poland (Manikowska, 1995; Kowalkowski et al., 1999; Kozarski and Nowaczyk, 1991; Kozarski et al., 1969). This difference might reflect the increasing continental climate regime towards the east. Due to the lower temporal resolution of luminescence in older sediments, a correlation of the aeolian sediments with distinct early Holocene climate oscillations is often not possible.

2.3. Summary

Summarising the available evidence, the early Holocene climate oscillations were cold spells in central and northern Europe. Many records point clearly towards dry conditions during the PBO, the 9300 cal BP and the 8200 cal BP phases. Examples are tree ring records, slope erosions (probably triggered by wildfires) with contemporary sparse evidence for increased flooding activity (overbank fines) and the detection of varying paleolimnological response (with allochthonous input in catchments under conifer forests and without in catchments under mixed deciduous forests). Consequently, besides cooler temperatures (winters, summers), deducible impact that lasted for several decades would be a strong reduction of freshwater sources for vegetation, fauna, and humans during the climate oscillation phases (Crombé, 2017).

3. Settlements and landscapes along rivers, lakes, and at the seashore

Since many ecological changes were triggered or bolstered by climatic events, changing landscapes are relevant factors to take into account when addressing human settlements, riverbanks, and especially seashores in the Baltic Sea area. This holds true not only for the ecological setting but also for the discovery of the sites and, finally, their interpretation. While postglacial processes caused the inundation of vast dryland areas at the coast and in some of the inland areas in the focus area, further inland erosions played another part.

3.1. The hinterland

Though the hinterland of the Northern European Lowlands has been less influenced by the postglacial land upheaval and subsidence, those processes had nonetheless consequences for Early and Mid-Holocene people. The changes in the shape of the Baltic Sea affected communication corridors and social spheres by blocking old and creating new waterways and land bridges. Being less subject to the tilting of the Scandinavian shelf and thus directly drowning or rising landscapes, Northern German sites are less directly affected by these geological processes, as long as they are not directly located at the coast (e.g. Goldhammer, 2008; Goldhammer and Hartz, 2017; Hartz et al., 2014; Lübke, 2009; Lübke et al., 2011). Nonetheless, the most northern and north-eastern parts of Germany were mainly transformed by the Weichselian glacier which created a highly diverse landscape in glacial and early postglacial times. Therefore, all archaeological investigations that are dealing with the Early and Mid-Holocene have to take a constantly changing landscape into account with frequently changing vegetation, lakes and rivers as well as the different predecessors of the Baltic Sea. Eventually, this also affected humans who had to adapt their different spheres of life, such as infrastructural, communication and settlement strategies.

While communication and infrastructure are more difficult to reconstruct, the settlement strategy is quite well-understood in the Early Mesolithic. Having access to larger water bodies and river systems seems to have been an important aspect for these hunter-gatherers. As a consequence to the settlement strategies, i.e. settling close to lakes or at the coast, several persistent places (Schlanger, 1992) are preserved until today. Overgrowing processes in the hinterland or inundation at the coast preserved partly extraordinary artefact spectra that allow an insight into Mesolithic lifeways (e.g. Glykou, 2016; Goldhammer, 2008; Goldhammer and Hartz, 2017; Gramsch, 2002; Groβ, 2017; Hartz et al., 2014; Lübke, 2009; Lübke et al., 2011; Schacht and Bogen, 2001; Schuldt, 1961a).

Hohen Viecheln is such a site that was found at the northern shore of Lake Schwerin which fills the remains of a pleni-glacially formed tongue basin of the Weichselian ice sheet. Even though the lake is located only ca. 15 km south of the Baltic Sea coast nowadays, it has always drained towards the Northern Sea, due to a sander ridge that constituted a watershed between both seas before an artificial channel ("Wallensteingraben") was built in 1531 to establish a connection to the Baltic Sea for transport. Stray finds show that the area was settled by hunter-gatherers already since the Late Palaeolithic at least (cf. Gramsch, 1987; Kasbohm, 1958). However, the most extensive record is known from the Mesolithic, even though the settlement itself was mainly destroyed during the construction of the *Wallensteingraben* in the 16th century. It has been shown by Gehl (1961) that in prehistoric times it was located at the end of a rather deep bight which is part of a tunnel valley.

During occupation, the bight was subject to silting up by gyttja in the deeper parts and it was overgrown by peat (Gehl, 1961; Schmitz, 1961). This process lasted until the Boreal/Atlantic transition around ca. 9200 cal BP when a rising lake level flooded the settlement area and repeatedly caused erosions at the cliff to the north of it. Consequently, sand was deposited on top of the organogenic layers and caused their compression (Gehl, 1961). Finds from the eroded sand show that parts of the former settlement were already naturally destroyed before the building of the *Wallensteingraben* in the 16th century. During the Neolithic, another peaty/humic layer was formed (Gehl, 1961; Schuldt, 1961b). The Mesolithic occupation dates mainly to the Early- and beginning Mid-Holocene (Schuldt, 1961b; Groβ et al., in prep.). The location of the site shows an obvious and specific choice of the area for settling. The long occupation sequence further highlights the special significance of the site, which may have been chosen due to protective but maybe also strategic reasons.

A comparable picture can be drawn for the Early Mesolithic sites in Friesack (e.g. Gramsch, 2002, 2014; Groβ, 2017) where several early Holocene occupations on two small island in an lakescape have been analysed. The sites were located in the Warsaw-Berlin ice-margin valley which formed a swampy lake land during time of occupation and thus a nutrient-rich ecosystem (cf. Whittaker, 1970, tab. 4–2). Both regions have to be seen as entangled in a

wider settlement system that is characterised by ecoregion continuity (Gramsch, 2002, 88) which is represented by multiple occupations and long-term use of the same places over centuries. A different example are the sites in the Duvensee peat bog where such a continuity in a region can be traced as well, but the single sites have only been settled for single events or subsequently within a rather short time (e.g. Bokelmann, 2012).

3.2. Lakescapes

The presented case studies of well-preserved Mesolithic sites show a high potential for understanding the surrounding landscape and the role of the sites in their respective settings. Being able to reconstruct the palaeo-environment helps to understand local conditions, but embedding them into their wider ecological and cultural context gains a growing relevance for archaeological research and interpreting prehistoric decision-making. While the aforementioned studies have provided sound evidence on rather local sites, contextualizing them is even more urgent when trying to analyse different human reactions to ecological changes and cultural transformations. Consequently, several current projects address specific environments or meso-regions for analysing past human behaviour.

For instance, the project pilot entitled Lost Inland Landscapes (LIL) by the University of Helsinki was launched in 2015 and is currently underway. A desk-based evaluation constitutes the basis for planning the activities and archaeological fieldwork in the largest lake complex in Finland, Lake Saimaa. Being located in the eastern part of Finland, the Saimaa basin has constituted one of the major inland water systems throughout millennia. After isolation from the Yoldia Sea, ca. 11,000 cal. BP, the water level of the lake was very low; in the southernmost areas as much as ca. 20 metres below the present levels (Pajunen, 2005). Due to the uneven postglacial rebound and lake tilting, the Saimaa basin continued to transgress towards the southeast direction and by ca. 6000 cal. BP the lower Lake Saimaa reached its maximum extent, nearly 730 km^2 in size (Pajunen, 2000, 2005; Saarnisto, 1970). The transgression culminated in the outburst of the Vuoksi River in the south ca. 5900 cal. BP (e.g. Oinonen et al., 2014; Saarnisto, 1970), which lowered the water level of the great lake rapidly. Because of this, the Mesolithic and Early Neolithic sites predating the transgression are to be found under water and in wetlands surrounding the lake. Due to the inundation of huge dryland areas, some underwater peat layers and submerged tree stumps have been found in various locations in the Saimaa lakebed. These features have been investigated through echo-sounding, coring, and 14C dating by geologists in order to reveal the early Holocene changes in the sedimentation environment (Pajunen, 2005). Surprisingly, archaeological interest in these submerged landscapes has been relatively scarce, even though securely-dated wood samples taken from the underwater tree stumps (Heikkinen, 1971) have yielded Early and Mid-Holocene dates, ranging between 9500 and 6700 cal. BP. New stumps appear every year during periods of low water through notifications by sport divers and fishermen. Based on palynological studies conducted in Taipalsaari, South Karelia, human activity has influenced local landscape and vegetation from ca. 8000 cal. BP onwards (Vuorela and Kankainen, 1993).

Not many archaeological campaigns have previously aimed at exploring these inundated landscapes with high potential for submerged Mesolithic archaeology, except for a few small-scale underwater archaeological projects in the late 1990s (Vikkula, 1994; Koivikko, 2000), where some quartz scatters and heaps of fire-cracked stones were observed in shallow water. Therefore, a field survey that was concentrating on wetlands and shallow water was conducted in South Karelia in 2015. Geophysical prospection, coring, pollen sampling, test pitting, underwater survey, and wetland excavations are currently underway at the Rajalamminsuo mire area in Savitaipale and underwater survey at the submerged Mesolithic forests in Taipalsaari, at the southern lake Saimaa area, commenced in 2017. During the first period of fieldwork in 2015, it was revealed that dense vegetation, water-saturation, and strong wave erosion render fieldwork ineffective in many wetland and littoral zones in this area and more invasive methods, such as coring and test-pitting, would be needed to detect deeply buried archaeological remains. Surveying the surroundings of the known Prehistoric sites, subsequent to the outburst of the Vuoksi River ca. 5900 cal. BP, was found useful because the sites' wetland archaeological potential had not been evaluated previously. Some of the sites are situated adjacent to mires and overgrown waterways and there may be organic archaeological remains preserved representing earlier habitation phases in certain lake levels in the same areas. Some sites also turned out to be more widespread than previously thought and a coring experiment conducted at an overgrown bay in front of a (Sub-)Neolithic site Ketvele in Taipalsaari revealed artefacts and sooty sand layers underneath saturated peat.

3.3. Settlements and seascapes

Another example of an integrated approach to Early and Mid-Holocene landscapes can be found off the southern Swedish coast. The Haväng site is situated at the river-mouth of the Verkeån River, which has its outlet in the Hanö Bay (Fig. 3). Here, a submerged landscape with excellent preservation conditions stretches from the shoreline down to a depth of 25 m b.s.l., about 3 km off the present coastline. Remnants from a landscape formed during two low-water phases, the Yoldia Sea and Ancylus Lake stages (ca. 11700-10300 cal. BP) and the Initial Littorina Sea stage (ca. 9800-8000 cal. BP), can be found on the seafloor. The site is being investigated by divers, which together with sediment corings and bathymetric analyses form the foundation of the research. Organic sediment ridges outlining the former path of the Verkeån River are found on the seafloor consisting of a detritus gyttja in the inner part and a calcareous gyttja in the middle and outer parts of the submerged landscape (Hansson et al., 2016). The ridges rise approximately 1 m above the surrounding seafloor, but in extreme cases the ridges rise up to 3 m above the seafloor. Remains of pine trees were found all across the seafloor in close proximity to the sediment ridges, both rooted stumps and fallen stems (Hansson et al., 2016). The trees are well-preserved and in some cases even the bark remains (Hansson et al., 2017a). Signs of human activity is seen across the seafloor; bones and antler, wooden torches, hazelnuts and manifest fishing structures (Nilsson et al., 2017). Around 9000 cal. BP the Haväng area developed into a lagoon (Hansson et al., 2016, 2017b). A sediment accumulation rate of close to 1 cm per year indicates both a high aquatic productivity and a large supply of terrestrial detritus. Freshwater dominated the basin, however, with a weak but consistent brackish influence. At the onset of the Littorina transgression the sea started to submerge the lagoonal landscape, which is seen in changes in the elemental contents and the deposition rate. The local vegetation was an open forest which was dominated by birch and alder along the lagoon shores, while pine and deciduous trees were found in the surrounding landscape.

A further example of the strategies employed to reveal the archaeological potential of a site can be shown by studies on the western Baltic shores of southern Denmark. Here, the rising sea level has the potential to provide excellent preservation of archaeological evidence in a region where other inundated Stone Age finds near coastal sites are known. Close to Rødbyhavn the

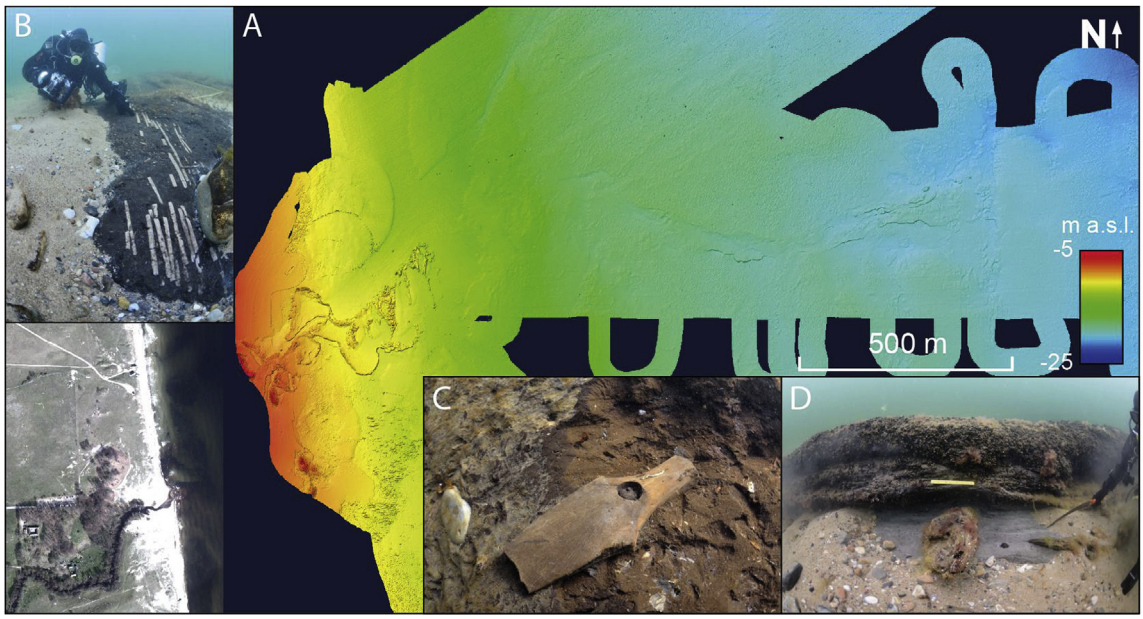

Fig. 3. A: Bathymetric map of the Haväng site. The Verkeån River is seen in the bottom left corner. During times of lower water level the river continued out in the exposed landscape and remnants of this can be seen on the seafloor today (aerial photograph © Lantmäteriet, multibeam survey MMT/Landscape Lost project 2013, and Sjöfartsverket 2014). B: Manifest fishing structure found in the inner part of the site made of hazel rods dated to about 9000 cal BP. C: Elk antler pickaxe, about 20 cm in length, found in a refuse layer in the organic sediments. The axe is dated to 8900-8700 cal BP. D: Tree stem protruding from a calcareous gyttja deposited during the Ancylus transgression. A brown detritus gyttja deposited during the Initial Littorina Sea stage is overlying the calcareous gyttja (photographs B–D: Arne Sjöström). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

construction of a fixed link to Puttgarden (Germany), the *Femern link*, involves the assessment of the archaeological potential of 187 ha of reclaimed land (Mortensen et al., 2015). The area was drained and dammed after a fatal storm in 1872 and has since been heavily cultivated. Due to this drainage, access is somewhat less restricted than in the aforementioned underwater examples but the challenge of finding these potential sites in such a large expanse involved customising more traditional survey methods to suit this particular area. *The Fehmarn Link* archaeological project is in effect a marine archaeological investigation conducted on dry land. The excavations have yielded evidence of the Mesolithic and Neolithic along with earlier material from the Ahrensburgian.

With a groundwater level of only ca. 0.5 m below surface and thick overlying sand deposits, it became quickly apparent that prospecting for potential archaeology with a series of trenches would not be possible. The strategy employed was to drill a tight grid of boreholes over the whole area which were sieved and analysed for cultural material. The identified 'hot spots' were then further investigated using box trenches and, later, some larger areas were drained and excavated. Stratigraphic and sedimentological data is available from over 400 boreholes and this data has now been further used to reconstruct the pre-sea level rise topography and the sea level rise that is associated to changing environments beneath this now very flat and featureless landscape. Parts of the stratigraphy are complex with zones of erosion and re-deposition which could be clearly seen in the profiles of later excavations. A simplified stratigraphic sequence common to the majority of the borehole data is therefore applied to reconstruct the pre-sea level rise topography and the changing dryland-shallow water-marine sequence.

Here is briefly described the reconstruction of the topography prior to the sea level rise which has yielded both Ahrensburgian and Ertebølle sites within a forested landscape. All suitable data was uploaded into a surface mapping programme and modelled using the XYZ sedimentary boundaries and kriging gridding. This gridding option compensates for clustered data and interpolates between missing data points. As shown in Fig. 4 the model reveals two distinct shallow fjords beneath the now extremely flat topography of the reclaimed area. The deepest part of the eastern fjord lies at 3.8 m below present sea level (m.b.s.l.). Many of the identified archaeological sites cluster between −2.5 and −2.0 m.b.s.l. whereas the deepest part of the western fjord is at −3.2 m.b.s.l. with sites mainly at higher elevations than the eastern fjord. Further analyses of the sediments, stratigraphy and its chronology are ongoing and will detail the changes in local geochemistry, vegetation, salinity and water depths and changes in the wider vegetation associated with the rising sea level. This work will help to connect the different types of sites (ritual, economic etc.) identified during *The Fehmarn Link* archaeological project to both their local environment and to the wider landscape.

3.4. Summary

The presented studies underline that careful preliminary work is essential when submerged and paludified Mesolithic sites are sought in wetland types of environment. By including palaeoenvironmental and geological data a more solid understanding of past landscapes and human interaction can be obtained. The examples show clearly that desk-based evaluation, palaeoenvironmental reconstructions, systematic survey, and a selection of invasive methods can yield a vast body of information before extensive fieldwork is conducted.

4. Hunter-gatherer behaviour, riverbanks and seashores

Even though the detection of Prehistoric sites is supported by a vast and growing variety of methods and techniques, understanding the behaviour of people bears several challenges that are addressed below. For this article, it is important to note that a similarity in location or archaeological finds do not necessarily

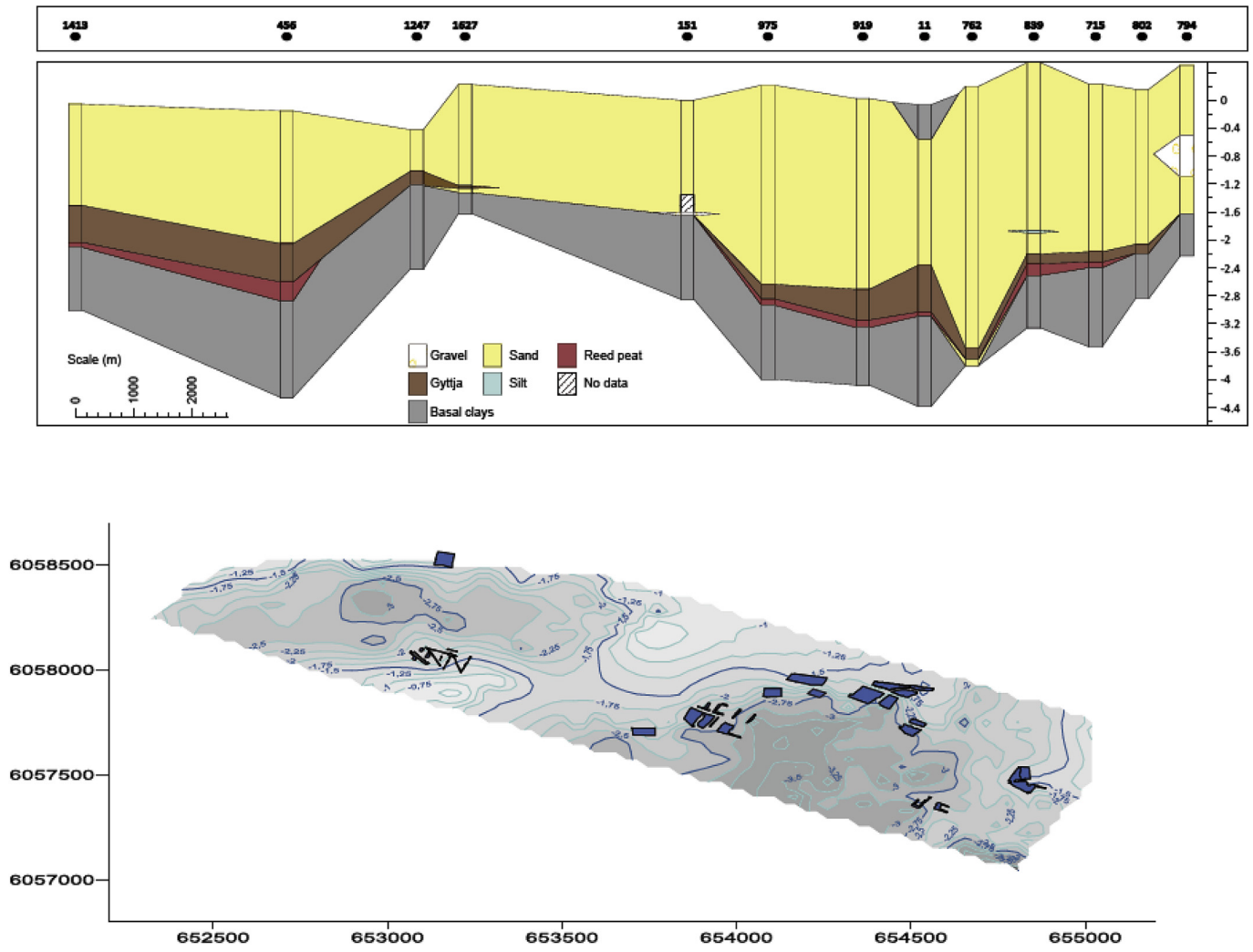

Fig. 4. The Femern link project. Top: A transect of the boreholes east-west in the central part of the area showing the pre-sea level rise topography and the overlying peat, gyttja and sands. Bottom: A modelled reconstruction of the pre-sea level rise contours and showing the major identified sites.

implicate similar social processes, behaviours, or intentions (cf. Binford, 1972; Clark, 1992; Newell and Constandse-Westermann, 1996; Wiessner, 1982; Yellen, 1977). Taking this into consideration, several models were developed for analysing archaeological remains.

4.1. Settlement location

Models of human behaviour are subject to their own limitations and shortcomings. For instance, this is shown by the traditional, relatively simplistic models of how hunter-gatherer settlements were supposedly located along riverbanks and seashores (e.g. the 'adjacent to the water' & 'fishing site' models (c.f. Fischer and Sørensen, 1983; Fischer, 2004; Grøn, 2012, 2015a, 2015b)). These models are currently under review on the basis of new archaeological and ethnoarchaeological data. During the last years, it became apparent that much more complex behaviours are in play that cannot directly be inferred from the location of sites alone: for instance, sites relying to a significant degree on marine resources can be located several kilometres inland from the contemporaneous seashores and central inland sites can be located several kilometres from the banks of rivers and lakes (Grøn, 2012, 2015a, 2015b; Haws et al., 2011 and examples below).

Whereas these, in some cases massive, deviations from archaeological 'text-book behaviour' are not possible to understand in detail at present, a number of elements can serve as a kind of explanatory back-drop. One important aspect is that the modelling of site locations is often based on topography alone and thus ignores the vegetation, for instance, which is often organised in complicated small-scale landscape mosaics underpinning a complex resource and settlement organisation in the landscape (e.g. Bird et al., 2016; Hansson et al., 1995; Kellet and Jones, 2017; Odum and Barrett, 1971). As a consequence the role of trees and bushes as protective landscape elements is ignored even though some ethnoarchaeological studies show that humans will – if possible – use trees as a protection against sun and wind (e.g. Bartram et al., 1991; Grøn et al., 1999). Incorporating palaeo-environmental reconstructions into analyses of settlement locations and eventually also behaviour of prey and other resources may therefore render possible a much more realistic understanding of prehistoric settlement patterns than geography alone. Likewise, it is still important to understand general patterns and taphonomic processes (Flemming et al., 2017). Consequently, we think that approaching questions of settlement location should be addressed from a multi-scale, i.e. local and (over-)regional, perspective.

Also a number of other factors can play a role for the precise

location of settlements which are connected to landscape, moisture, and/or vegetation. Also mosquitoes and other annoying insects, access to firewood or configurations of river features that generate accumulations of driftwood, good fishing grounds, or access to water can be relevant – apart from winter settlements where one can drink melted snow (Grøn, 2012; Kellet and Jones, 2017). At least in some cases it is also important to note that central settlements and features are fairly visible and thus serve as 'territorial markers' to other groups passing through a territory (Grøn et al., 2008).

Deciding on a new settlement site/area is usually a compromise that involves a large amount of factors which also include social/distance-related aspects. Recent reports from Evenks, indigenous people from northern Asia, exemplify this: A and B like to play cards together and should therefore not be further away from each other than that one can walk to the other's camp in one day, when the clan is spread in the landscape. Another record shows that C has got no wife and likes to visit D, E's wife, when E is not at home, therefore their camps should not be too far from each other (Grøn, 2012). In the latter case, apparently everybody in the clan knew about the intimate relation between C and D but never mentioned it openly.

4.2. The role of vegetation

From an archaeological perspective it becomes apparent that the vegetation of natural landscapes is often highly dynamic since the ecological succession involves an asynchronous development of the different parts of the landscape mosaic. After the natural burning of an area, which is lightning ignited, the vegetation starts a development to become a 'climax biotope' that will then again burn down (Odum and Barrett, 1971). Different types of vegetation will burn in different ways. Moisture, wind direction and speed in relation to slope, seasonal development of the vegetation, etc. will determine the type of fire, and its consequences (Lewis, 1973; Pyne, 2011). Such small-scale vegetation dynamics are often so fast, that a temporal-spatial reconstruction is impossible due to – among other things - the resolution of our dating methods (Innes et al., 2004). The distribution and behaviour of the resources (flora and fauna) in a dynamic mosaic landscape is thus difficult to reconstruct in all particularities. This becomes even more challenging when deviations from more simple models appear due to conscious human manipulation of resources in their environment - including both vegetation and animal populations. Such strategies seem to be much more common in hunter-gatherers than hitherto assumed in archaeology (Archibald et al., 2012; Bird et al., 2016; Grøn, 2012; Lewis, 1973; Morgan et al., 2017; Pyne, 2011).

4.3. Coping and subsistence strategies

Another important point is that different cultural groups demonstrate quite different strategic behaviours in similar and even identical landscape situations. This has hardly been touched upon, but some remarkable ethnoarchaeological and archaeological examples have appeared in the discussion which indicate that a better understanding of this dimension of complexity is important for our ability to deal with Prehistoric settlement patterns. A well-documented archaeological example is the appearance of the Thule Culture in Alaska around 900 AD. This culture's subsistence was based on a much broader exploitation of the available maritime resources and the employment of a wider range of hunting techniques than the earlier Birknirk/Norton cultures in the area. The Thule Culture represents a strategic shift from whale group hunting, which was possible only in a few coastal locations, to the targeting of single individuals, such as bowhead whales, by using small highly mobile crews in the open sea. Furthermore, blubber lamps were introduced as a heating source supplementing the firewood hearths. The new resource strategy is consistent with a shift from relatively few large villages to a larger number of smaller settlements. The Thule culture's fast dispersal and replacement of the Dorset Culture around 1000 AD in large parts of Canada and 1200 AD in Greenland most likely reflects that it was highly successful (Gulløv, 2004; McGhee, 1984). This example is interesting because it involves the development of a new and apparently superior strategy for resource exploitation accompanied by a new and significantly different settlement pattern within a quite restricted time interval. This example is in good accordance with Murray's (1996, 123) central conclusion about the economies of the palaeo-eskimo cultures of the Foxe Basin, Canada:

"[…] it is clear that there was a wide range of economic options for Arctic peoples, despite a perception that this might not have been the case. While it is true that the number of different animal resources in the Arctic may have been limited, the ways in which humans chose to exploit available resources were highly variable. Economies varied temporally, geographically and culturally."

The importance of differences in hunter-gatherer groups' ideologies for their landscape behaviour is reflected in a comparison of the Evenk (Siberia) and the Mistassini Cree (Canada) winter settlement patterns: The two groups occupy quite comparable areas but the Evenk drink melted snow in winter and state that they prefer its taste to that of unfrozen water from rivers and lakes, which one must access through an often quite thick layer of covering ice. Contrary to this, the Mistassini Cree have a prohibition against drinking melted snow and ice and must therefore obtain un-frozen water through holes in the ice all winter. As a consequence, the Mistassini winter camps are always immediately adjacent to lakes or rivers, whereas the Evenk winter sites and winter hunting cabins can be up to 5 km from the nearest water (Grøn, 2012).

Keeping this in mind, it becomes obvious that the material culture alone does not necessarily help to understand human behaviour and social complexity, neither do studies of settlement or subsistence alone. While it is highly relevant to limit the scientific perspective due to practical reasons to single aspects of prehistoric life or environments, combining different approaches and perspectives is just as important. Generally, we think that further considerations of the social structure of Early and Mid-Holocene foragers around the Baltic Sea are needed. This is particularly important because the level of complexity among early Holocene foragers in coastal areas has long been debated and a high level of complexity and social stratification has been suggested in particular for the Late Mesolithic foragers of the Ertebølle culture (Price, 1985; Rowley-Conwy, 1983).

4.4. Territoriality

Territoriality is often considered as a signal of complexity among foraging societies (Price and Brown, 1985) though it varies depending on landscapes and available resources and their predictability (cf. Rowley-Conwy and Piper, 2016). Even though parallelising sub-recent foragers from different parts of the world and Early and Mid-Holocene hunter-gatherers from the Baltic region is methodologically difficult (e.g. Carlsson, 2008; Gosden, 1999; Kelly, 1995; Thomas, 2004), some traits might be useful to consider. Most territorial forager groups in North America live in areas with high seasonal abundance of primarily migrating fish, i.e. salmonids. While salmons do not appear to be of significance in the diet in the southern part of the Baltic (Boethius, 2018c), other fish species can be considered to generate equal amounts of seasonal abundance. Generally, the importance of fish in human subsistence is difficult

to investigate due to low quantities of fish bones at archaeological sites. However, this is likely influenced by excavation techniques because when dug with adequate methods large amounts of freshwater fish bones are usually recovered in suitable preservation contexts (Boethius, 2018b; Goldhammer, 2008, 35; Kjällquist et al., 2016; Robson, 2016), thus underlining the importance of fish at many Mesolithic settlements. Further indications for this staple was demonstrated by freshwater reservoir effects on radiocarbon-dated Mesolithic human bones from the Baltic area (e.g. Meadows et al., submitted, Boethius et al., 2017, Boethius and Ahlström, submitted). Stable isotope signals ($\delta^{13}C$ and $\delta^{15}N$) are traditionally used to study diet, but can, if applied to a large scale investigation, be used to study mobility trends. Especially the results from Scandinavia showed no or little overlap between the isotope signals from humans in different environments (Boethius and Ahlström, submitted): No human isotope overlaps between marine and freshwater environments during the Early Mesolithic period were found and only one clear overlap during the Middle Mesolithic period. This indicates limited coast to inland mobility, thus being an indicator for territoriality (Boethius, 2018c). Furthermore, features may indicate a certain territoriality or limited range, as for example in Norje Sunnansund. Here, large amounts of fish were fermented and conserved for later use, thus functioning as a long time storage (Boethius, 2016), which, due to the difficulties in moving this type of storage over long distances (Rowley-Conwy and Zvelebil, 1989), creates a link to the area and can be seen as a territorial indicator.

The aforementioned site Haväng, contemporary with the Norje Sunnansund site, shows similar patterns linked to mass catching of aquatic (lagoonal) resources. The stationary fishing equipment dated to 9000 cal BP must be understood in terms of early territorialisation (Nilsson, 2011; Nilsson et al., 2017). The larger fishing gears within the rivermouth functioned not only as a stable and reliable resource for food, but acted as a stable place in a more fluid and highly social landscape. Hence it might be fair to conclude that the construction and the continuous tending and use of the fish traps, also entrapped people. The importance of these hitherto quite unknown sites cannot be underestimated.

In the Late Mesolithic, cemeteries and burial grounds are often located on visible spots along the coastline (Larsson, 1988, 1993, 1995; Petersen et al., 2015) which signals another territorial link to the surrounding landscape (Layton and Rowley-Conwy, 2013). So far, no evidence has been found of such types of territorial displays. However, this does not necessarily mean that they did not exist, as most of the early Holocene coastline is currently submerged, and corresponding locations are thereby difficult to recover from earlier periods. Furthermore, there might also have been a shift in burial customs. It is possible that earlier burials of territorial significance, if existent, have been put on display on platforms in trees, as for example occurs among the Evenks (Grøn, 2015a). Such features would have only left scattered human remains on the settlements instead of actual graves - a type of find that is quite common (Boethius, 2018c; Gramsch and Ullrich, 2014; Meadows et al., submitted).

4.5. Summary

The several indicators combined suggest that from the Early Mesolithic period and onwards, we must not only consider high forager mobility, but also take into account sedentism, delayed return lifestyles and territoriality around the Baltic basin. This being generally valid, it is also important to consider a large variety of cultural expressions among these human societies. However, it is also essential to remember that if a foraging community settles in a favourable spot in the landscape, they will often claim control of the area (Kelly, 2013). Since sedentary societies living in favourable spots tend to expand more rapidly than mobile groups, especially if relying on aquatic resources as increased reliance on fish can be considered a response to population increase (Binford, 2001), they may also prevent other groups from entering their territory (Kelly, 2013).

5. Concluding perspective: The Baltic Sea basin in the early and Mid-Holocene

The increasing need for understanding entire landscapes in palaeoecological and archaeological research demands a consequent and open perspective. As our various case studies demonstrate, a combination of remote sensing, clastic or sedimentological analyses and extensive fieldwork are needed in order to obtain a large and detail-rich dataset for interpretations of Prehistoric landscapes. Against such a background, it is possible to see how cultures changed and why and when alterations in their manifestations became significant. Nevertheless, not only such parameters are needed to gain a full understanding of past realities, but also a multidisciplinary perspective and approach is required for this.

Due to the growing scepticism against simple and universal explanatory models (e.g. Grøn, 2015a) and the growing awareness of multi-faceted human behaviour (see above), understanding sites in their individual contexts, such as their internal structure, are of increasing importance (c.f. Grøn, 2017). Especially when dealing with diverse landscapes several aspects should be regarded since they affect the possible interpretation: Differences in preservation conditions, site representation and representativeness, excavation techniques, or sample location affect the basis for archaeological interpretation. Thus comparisons can already be skewed due to different pre-conditions and thus hardly provide a reliable basis for hypotheses on past realities. Several studies have shown how different preconditions affect the interpretational basis (e.g. Campbell et al., 2011; Goldhammer, 2008; Groß, 2017; Milner et al., 2011). Furthermore, some sites with good preservation conditions should not be the only basis for formulating hypotheses as they might be subject to specific conditions themselves. For instance, drowned sites (with consequently well preserved artefacts) at the southern Baltic coast might have been chosen in the past due to their proximity to the sea. Information about hinterland settlements is thus hardly to get from such inventories.

It has become clear that the possibilities for finding comparable sites is very different depending on the respective geological situation. Generally speaking, while Early and Mid-Holocene sites on the Scandinavian Shield are exposed in the landscape today due to isostatic uplift, other areas were consequently inundated and therefore much more difficult to discover and explore after all. But the latter usually provide more chances for preserving organic materials which can inform us a lot better about Prehistoric landscapes, subsistence and toolkits. A good example for this are the sites from Haväng, Norje Sunnansund, Rødby, Friesack, Duvensee, and Hohen Viecheln. Contrary to this, understanding the respective environment and embedding a site into its Prehistoric landscape usually demands a lot more investment than on uplifted dry land sites where rather straightforward approaches can be used – at least for a general picture.

The studies presented here are meant to give a brief and exemplary overview over the differences in archaeological and palaeoenvironmental research in a geographically distinct but diverse area. Our investigations show that the local characteristics of a landscape need to be integrated into studies and evaluated before trying to start overarching comparisons. While this is a truism, it nevertheless highlights the difficulty such studies are faced with. Nonetheless, we argue that there is a growing need to pursue a multidisciplinary approach for understanding processes of

social transformation, communication, transmission of ideas and migration in Prehistory. What has become clear as well is the fact that the same preconditions (or environments) do not necessarily lead to the same outcome or reaction. Human behaviour usually follows reasonability but this itself is culturally (or egotistically) overprinted. Thus, the same preconditions are not necessarily followed by the same coping mechanisms.

A common characteristic of the Baltic Sea basin and its hinterland is the fact that the Early and Mid-Holocene people inhabiting the area were largely relying on an aquatic landscape. While infrastructure might have played a very important aspect to these people too, not only for exchange but also supply, recent studies of human remains and subsistence underline the relevance of aquatic resources for subsistence (e.g. Boethius, 2016, 2017, 2018a, 2018b; Boethius et al., 2017; Fischer et al., 2007; Lidén et al., 2003; Meadows et al., submitted; Milner et al., 2003; Ritchie et al., 2016; Robson, 2016; Robson et al., 2016; Skar et al., 2016; Solheim and Persson, 2016; Terberger et al., 2015; Zabilska-Kunek et al., 2015). The people who lived in the area were integrally intertwined with their environment and thus had incorporated a lifestyle that was closely connected to lakes, riverbanks and seashores. However, parallel to this, the people have been subject to different influences during the Early and Mid-Holocene. As has been shown, various cultural and technological influences were present in the area (e.g. Clark, 1975; Damlien, 2016; Kobusiewicz, 2004; Sørensen et al., 2013, 2018; Zvelebil, 2008; Zagorska, 1995). While the cultural assignment was subject for academic discussion ever since, here, it is more relevant to provide an overview of the differences between sites and studies such as highlighting the bandwidth of variability. Before inter-site comparisons can be made, a common ground for comparison is needed (cf. d'Errico et al., 2017; Groß, 2017). Only after establishing such a comparative basis, which addresses aspects for cultural entanglement, material culture, ecology and geography from a comparable and comparative perspective, aspects may be discussed that lead to a further understanding of the past.

While it was not possible for this study to provide the same quality and regional focus for all sites presented, further research should explicitly aim to establish comparisons of various similar aspects and analyse them in comparable regions and timeframes over larger areas. This will render possible to carve out regional and socio-cultural differences on a much more solid basis than archaeological remains alone are able to. Such studies further need to present detailed environmental reconstructions so that diverse behaviours in different landscapes or regions can be observed.

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